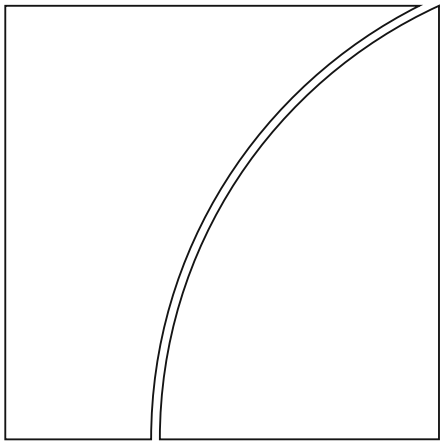
BANK FOR INTERNATIONAL SETTLEMENTS



BIS Working Papers

No 882

Corporate zombies: Anatomy and life cycle

by Ryan Banerjee and Boris Hofmann

Monetary and Economic Department

September 2020

JEL classification: D22, D24, E43, G33.

Keywords: zombie companies, firm behaviour, economic dynamism, productivity growth, bankruptcy.

BIS Working Papers are written by members of the Monetary and Economic Department of the Bank for International Settlements, and from time to time by other economists, and are published by the Bank. The papers are on subjects of topical interest and are technical in character. The views expressed in them are those of their authors and not necessarily the views of the BIS.

This publication is available on the BIS website (www.bis.org).

ISSN 1020-0959 (print)
ISSN 1682-7678 (online)

Corporate zombies: Anatomy and life cycle[1]

Ryan Banerjee[2]
Bank for International Settlements

Boris Hofmann[2]
Bank for International Settlements

ABSTRACT

Using firm-level data on listed non-financial companies in 14 advanced economies, we document a rise in the share of zombie firms, defined as unprofitable firms with low stock market valuation, from 4% in the late 1980s to 15% in 2017. These zombie firms are smaller, less productive, more leveraged and invest less in physical and intangible capital. Their performance deteriorates several years before zombification and remains significantly poorer than that of non-zombie firms in subsequent years. Over time, some 25% of zombie companies exited the market, while 60% exited from zombie status. However, recovered zombies underperform compared to firms that have never been zombies and they face a high probability of relapsing into zombie status.

Keywords: zombie companies, firm behaviour, economic dynamism, productivity growth, bankruptcy.

JEL classification: D22, D24, E43, G33.

---

[1] The views expressed in this paper are those of the authors and do not necessarily reflect those of the Bank for International Settlements. The authors thank Claudio Borio, Maria Canelli, Stijn Claessens, Sebastian Doerr, Martin Hood, Enisse Kharroubi, Benoît Mojon and Kostas Tsatsaronis as well as participants in the conference on "The effects of an ultra-low interest rate regime on banks and the economy", Imperial College, London, 12 December 2019, the Conference Board Economists and Strategy Council, 17 March 2020 and a BIS research meeting for helpful comments and suggestions.

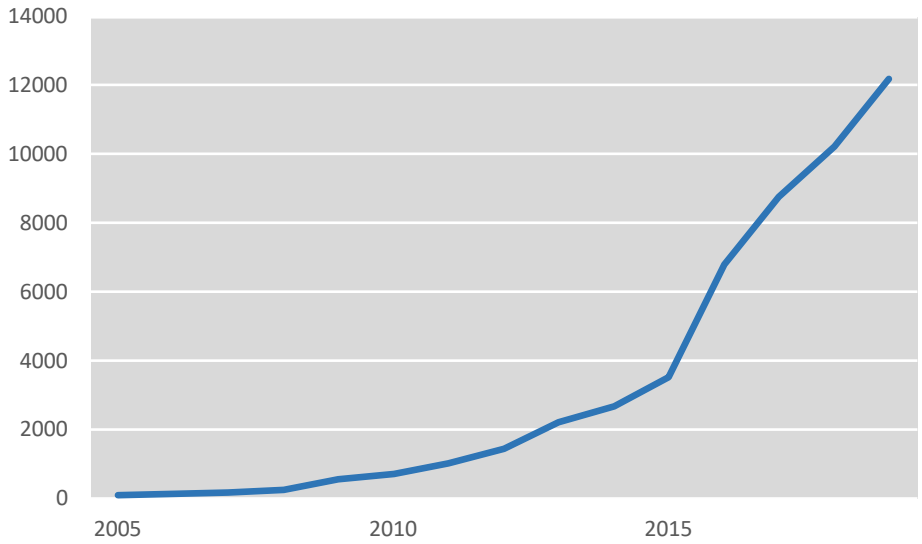
[2] Banerjee: ryan.banerjee@bis.org; Hofmann: boris.hofmann@bis.org

1. Introduction

The rising number of so-called zombie firms, generally defined as firms that are unprofitable but remain in the market rather than exiting through takeover or bankruptcy, has attracted increasing attention in the public debate (Graph 1)). The Covid-19 pandemic has given further impetus to this debate as the crisis puts severe strains on the corporate sector which governments seek to counteract through large-scale support measures (e.g. Financial Times (2020), Lynch (2020)).

The literature has so far focused largely on the causes and the consequences of the rise of these firms for other firms and for aggregate productivity. But little is known about the zombies themselves, except that they are commonly found to be less productive than their non-zombie peers.

The public debate about zombie firms[1] Graph 1



Cumulative number of times the words "zombie firms" or "zombie companies" appeared in English, German, French, Italian and Japanese-language newspapers and news magazines as well as in blog or board entries.

Sources: Authors' search in Factiva.

In this paper, we aim to fill this gap by exploring the anatomy and life cycle of zombie companies. Using firm-level data covering 14 advanced economies and spanning three decades, we identify zombie companies based on (i) their persistent lack of profitability, i.e. profits insufficient to cover interest payments on debt (interest coverage ratio below one); and (ii) poor expected future growth potential revealed through low equity valuations, i.e. a relatively low ratio of the market value of firm assets to their book value (relatively low Tobin's q). The data for the analysis are from the Worldscope database, providing annual financial statements of listed companies going back to the 1980s.

We explore the anatomy of zombie firms by analysing their characteristics and performance compared with those of non-zombie firms. To this end, we look, *inter alia*, at asset size, capital expenditure, intangible investment, employment, productivity, profitability, leverage, borrowing and equity issuance. As mentioned before, while the literature has extensively documented that zombie firms are less productive than their profitable peers, there has been very little analysis of other aspects of their anatomy.

To characterise the life cycle of zombie firms, we analyse the development of their balance sheet, profit and cash flow accounts in the years before and after they are first classified as zombies. This analysis sheds light on the questions of how companies turn into zombies and what happens to them afterwards. In this vein, we also assess how many zombie firms eventually died (exited the market) and how many recovered in a formal sense of not being identified as a zombie anymore by our criterion.

Finally, we zoom in on those firms that have managed to recover from zombie status. The number of these firms turns out to be rather high which raises the question whether the zombie problem is just an illusion. The answer to this question depends on the performance of the recovered zombies, whether they become fully normal firms or whether there are indications of some long-term damage from their previous zombification. To assess this point, we calculate the probability of recovered zombie firms relapsing into zombie status and compare their performance with those firms that have never been zombies.

The main results of our analysis are as follows.

First, we find that the number of zombie firms has on average risen significantly since the 1980s across the 14 advanced economies covered by our analysis. The number of zombies rose from about 4% of all listed firms in the mid-1980s to as many as 15% in 2017. The share of listed corporations' assets, capital and debt sunk in zombie firms is lower, at around 6%-7%.

These estimates however likely understate the number and economic weight of zombie firms. This is because our analysis focuses on listed companies which allows us to cover a much longer time span of data and to take into account in our zombie definition the perceived future growth potential as reflected in equity prices. Our analysis does therefore in particular not cover unlisted small and medium-sized enterprises (SMEs), which play an important role in many economies. If SMEs are more susceptible to zombification, then our analysis may understate the number and the economic weight of zombie firms. Indeed, we find that zombie shares are

considerably higher in Anglo-Saxon countries, where there is a higher propensity to list on the stock market, in particular for SMEs, than in continental European countries and in Japan. Moreover, we find that amongst listed SMEs, the share of zombie firms in assets, capital and debt is as high as 30%-40%.

Second, we find that zombies' anatomy differs significantly from that of their non-zombie peers. Specifically, we find that, compared with other firms, zombie companies are smaller, less productive, and grow less in terms of assets and employment, while spending less on physical and intangible capital. At the same time, they are more leveraged. However, their debt shrinks, albeit at a slower pace than their assets, and they issue more equity compared to other companies. We further find evidence that zombies receive "subsidised" credit as the interest they pay in their debt is not significantly higher than that of non-zombie firms despite their lower profitability and greater riskiness.

Third, the life cycle of zombie companies is marked by a number of key features. In the years before they become a zombie, they experience falling profitability, productivity, employment and investment. Initially they stay afloat by raising leverage and increasing equity issuance as well as by increasing asset disposals relative to non-zombie firms. After zombification, their performance remains significantly poorer than that of non-zombie firms. A zombie firm faces a significantly higher probability of exiting the market through bankruptcy or takeover, by about 10 percentage points cumulatively in the following four years (compared to non-zombie firms).

Fourth, out of the total number of zombie firms that emerged since the mid-1980s, about 25% have exited the market so far (died). Around 60% of zombie firms have managed to recover, meaning that they were at some point no longer identified as zombie firms by our criteria. The recovered zombie firms however remain weak and fragile. Their productivity, profitability, investment and employment growth remain well below those of non-zombies. Reflecting this weak performance, they face a high probability of relapsing into zombie state. By 2017, the probability of becoming a zombie firm in the subsequent year was, at 17%, three times higher for a recovered zombie compared to a firm that has never been a zombie firm. This relapse probability of recovered zombies has increased more than threefold over the past decade.

Related literature

Our paper contributes to the growing literature on zombie firms and their wider economic causes and consequences. The phenomenon was first observed in Japan,

where the emergence of zombie companies was highlighted as a potentially important reason for Japan's lost decade (Caballero et al. (2008)). Adalet McGowan et al. (2017) have documented that the number of zombie firms has increased significantly across the advanced economies in the wake of the Great Financial Crisis (GFC), while Banerjee and Hofmann (2018) document a longer-lasting trend increase since the 1980s. These studies find that the main consequence of zombie firms is reduced economic dynamism and performance. Specifically, zombie firms are found to be less productive and at the same time create congestion effects for other, more productive firms.

With respect to the causes, the literature has identified weak banks as a key factor behind the emergence of zombie firms. Caballero et al. (2008) find that the rise of zombie firms in Japan in the 1990s was linked to weakly capitalised banks which evergreened loans to avoid charge-offs that would have pushed them against regulatory capital limits. More recently, Storz et al. (2017) and Schivardi et al. (2017) document a similar link between weak banks and zombies in the wake of the GFC. Andrews and Petroulakis (2017) highlight the role of bankruptcy laws. They present cross-country evidence suggesting that bankruptcy laws which inhibit corporate restructuring are associated with a greater prevalence of zombie firms.

Press commentaries often point to persistent low interest rates as a key driver of corporate zombification (e.g. Sharma (2019), Taylor (2019), Armstrong (2020)), as they reduce debt service burdens and may induce banks or creditors more generally to evergreen loans to non-viable firms. Yet, analytical studies that formally explore this link are, so far, few. Acharya et al. (2019a) find that euro area banks used the capital gains on their bond holdings arising from the launch of the ECB's Outright Monetary Transactions (OMT) in 2012 to increase credit supply mainly to low-quality firms with which they had pre-existing lending relationships. Banerjee and Hofmann (2018) present evidence of a positive link between low rates and the number of zombie companies at the country and at the sectoral level.

The remainder of the paper is organised as follows. Section 2 describes how zombie companies are identified in our analysis. Section 3 provides key facts on the anatomy of zombie firms. In Section 4, we explore the life cycle of zombies, analysing what happened to a firm before and after it became a zombie. Section 5 zooms in on the recovered zombie firms. Section 6 concludes.

2. Identifying zombie firms

We define a zombie company based on a persistent lack of profitability and low stock market valuation. The rationale for this definition is that firms which cannot generate profits over an extended period and whose stock market valuation suggests that they will also not do so in the future should normally exit the market.[3]

Specifically, we classify a firm as a zombie if over two years (i) its interest rate coverage ratio (ICR), defined as earnings before interest and taxes (EBIT) over interest payments, is below one and (ii) the ratio of its assets' market value to replacement cost (Tobin's q) is below the median within its sector.[4] We require some persistence in the lack of profitability and low stock market valuations in order to mitigate the effect of transitory fluctuations of profits and stock prices on the classification. In this vein, we also require a firm to have an ICR larger than one or a Tobin's q above the median also for two consecutive years before it is declassified as a zombie firm. In other words, we require also some persistency in performance improvement before a firm is counted as recovered from zombie status.[5]

Our definition extends profitability-based zombie definitions adopted in previous studies (e.g. Adalet McGowan et al. (2017), Storz et al. (2017), Schivardi et al. (2017)) by adding the requirement that the firm also has a low future profit potential in the eyes of investors as reflected in a relatively low Tobin's q. The purpose of this extension is to avoid characterising firms that may make losses

[3] An alternative criterion proposed in the literature is whether a firm is receiving "subsidised" credit. Caballero et al. (2008) and Acharya et al. (2018) identify zombie firms as companies that received "subsidised" credit at rates below those for the most creditworthy companies. The idea behind this criterion is that receiving subsidised credit is an indication of lack of viability under regular funding conditions. This identification however has a number of potential drawbacks. First, banks may grant subsidised credit for other reasons than keeping an unviable firm alive, e.g. because of long-standing credit relationships. Second, when interest rates are very low for a long time, subsidised lending rates would have to be near zero or even negative, which is in practice rarely the case. For these reasons, we prefer a definition that rests on persistent lack of profitability and low stock valuation. We however test whether there is evidence that the zombies identified by our criteria have received subsidised credit by comparing their interest payments with those of non-zombie firms.

[4] We use a relative rather than absolute criterion for Tobin's q in order to avoid that general stock market swings drive the zombie firm count. If we were using an absolute criterion for Tobin's q, general stock market booms would artificially reduce the identified number of zombies, while busts would artificially inflate it.

[5] It is important to note, however, that the precise specification of our zombie definition with respect to the number of years the criteria have to be met on the way in or out of zombie status (i.e. one year, two years or three consecutive years) does not qualitatively affect any of the results.

today but are seen as profitable in the future as zombie firms. This also helps to avoid mis-classifying young start-ups that may need some warm-up time to generate profits but are seen by markets as being profitable in the future as zombies.

In the previous literature, this consideration was often sought to be taken care of by an age restriction. For instance, Adalet McGowan et al. (2017) define zombies as firms with an ICR persistently below one and an age of at least ten years. The drawback of this approach is that firms that are younger than ten years are ruled out to be zombie firms by definition, although it is not clear *a priori* why younger firms could not be unviable. At the same time, it is not clear why older loss making firms could not have high growth potential. Indeed, Banerjee and Hofmann (2018) show that zombie firms identified based on the criteria suggested by Adalet McGowan et al. (2017) have on average a Tobin's q that is higher than that of non-zombies, indicating that there are many firms in this group that markets perceive to have high profit potential.[6]

The analysis is based on firm-level data from the Worldscope database, which provides financial statement data for listed companies. We examine a sample of almost 32,000 publicly quoted firms from 14 OECD countries going as far back as 1980. Focusing on publicly quoted firms has two main advantages. First, the longer time span of data on these firms allows analysis over several business cycles. Second, it is possible to take into account the perceived future growth potential as reflected in equity prices, which is a defining criterion in our zombie definition. A drawback is that publicly quoted firms are not fully representative for the whole population of companies in the economy, implying that, as already noted above, our findings have to be put into perspective.

The data suggest that the presence of zombies has increased significantly since the mid-1980s. Graph 2 shows the evolution of the share of firms classified as zombies in the total population of listed firms (blue line). Across 14 advanced economies, the share rose by 2017, on average, to 15%. This is a more than threefold increase from the level of around 4% that prevailed in the late 1980s.

---

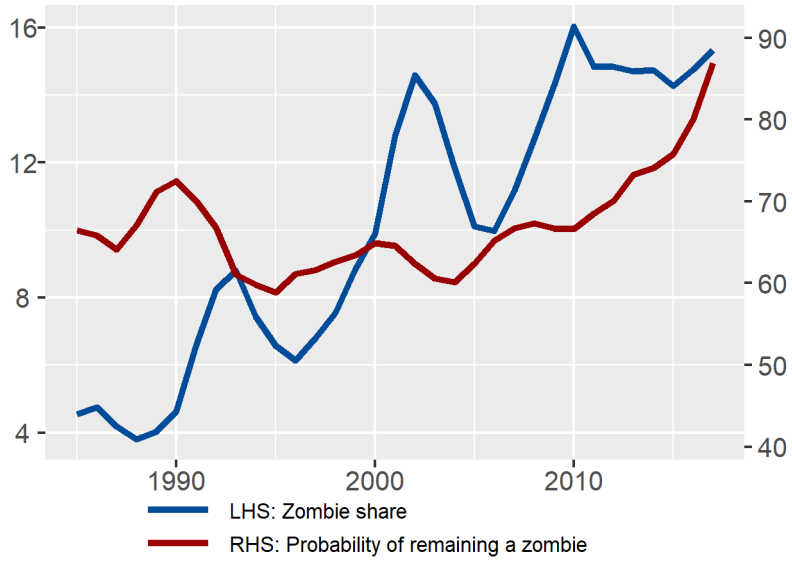
6 Banerjee and Hofmann (2018) further show that only when the requirement of a below median Tobin's q is added to the original zombie definition of Adalet McGowan et al. (2017), are significantly negative zombie congestion and overall productivity effects obtained. Specifically, they show that only with such a narrower definition, a higher share of zombie firms in a sector exerts a negative effect on employment and investment of non-zombie firms in the same sector and a higher share of zombie firms in a country exerts a negative effect on overall productivity growth. The zombie definition adopted in this paper is slightly different from the narrower definition in Banerjee and Hofmann (2018), in particular by not including a firm age criterion. In Appendix 1 we show that also under the definition adopted in this paper, significantly negative congestion and aggregate productivity effects obtain.

The increase was not steady. Upward shifts linked to economic downturns in the early 1990s, the early 2000s and in 2008 were only partly reversed in subsequent years. The increase that occurred in the wake of the GFC was more persistent than the previous rises. The zombie share peaked in 2010 at 16% and declined in the subsequent recovery by a mere 2 percentage points. Since 2015, the share of zombie companies is already rising again, reaching again 15% in 2017.

Zombie share and persistence[1]

In per cent

Graph 2



[1] Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declasssified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required. The probability of remaining a zombie firm is calculated as the number of firms that are classified a zombie in year *t* that remain a zombie in year *t+1* divided by the number of firms that are classified a zombie in year *t*.

Sources: Datastream Worldscope; authors' calculations.

At the same time, there has been a greater persistence in zombification, with firms staying in a zombie state for longer. Graph 2 reports the evolution over time of the probability of a firm remaining in the zombie state from one year to the next (red line). This probability is calculated as the number of firms that are classified as a zombie in year *t* and that remain a zombie in year *t+1* divided by the number of firms that are classified as a zombie in year *t*. The chart shows that the probability of a zombie remaining a zombie in the following year rose from around 70% in the late 1980s to 85% in 2017.

The aggregate figures conceal considerable heterogeneity in the presence of zombie firms across countries (Graph 3). Specifically, we find that the zombie share is highest in Anglo-Saxon countries. Australia and Canada register the highest

zombie shares in 2017, ranging around 30%, and also in the United Kingdom and the United States the numbers are quite high, near 20%. In this group of countries, except for Australia, zombie shares have kept on rising in the wake of the GFC. In continental Europe the zombie shares are lower, ranging from 10% to 15% and have stayed flat or were falling after the GFC. The exception is France, where the share more than doubled since 2008. Also in Japan, the zombie share is currently low at around 3%. Our analysis reproduces the sharp rise in Japanese zombie firms in the 1990s, as documented in Caballero et al. (2008) and the subsequent decline associated with the clean-up and recapitalisation of the Japanese banking sector in the 2000s.[7]

Differences in the propensity to list on stock markets across countries explain at least part of these cross-country differences. As mentioned before, our dataset only includes listed corporates – as we make use of stock market valuations to identify zombie firms. However, the propensity of firms to list is very heterogeneous across economies. Anglo-Saxon economies tend to have more listed firms, including in particular also more listed SMEs. The share of SMEs (defined as firms with an annual turnover of less than 50 million US dollar)[8] in all listed firms in 2017 was on average 50% in the four Anglo-Saxon countries, 28% in the nine continental European countries and just 15% in Japan. As SMEs are more likely to be zombies as we will show below, the higher zombie share in Anglo-Saxon economies reflects in part their higher share of SMEs among listed companies. Put differently, the underrepresentation of SMEs in the group of listed firms in continental Europe and Japan means that the true zombie share in these economies is probably higher than our estimates suggest. Our estimates of zombie shares for these countries, and therefore also for the aggregate reported in Figure 2, should therefore be seen as conservative lower bounds.

---

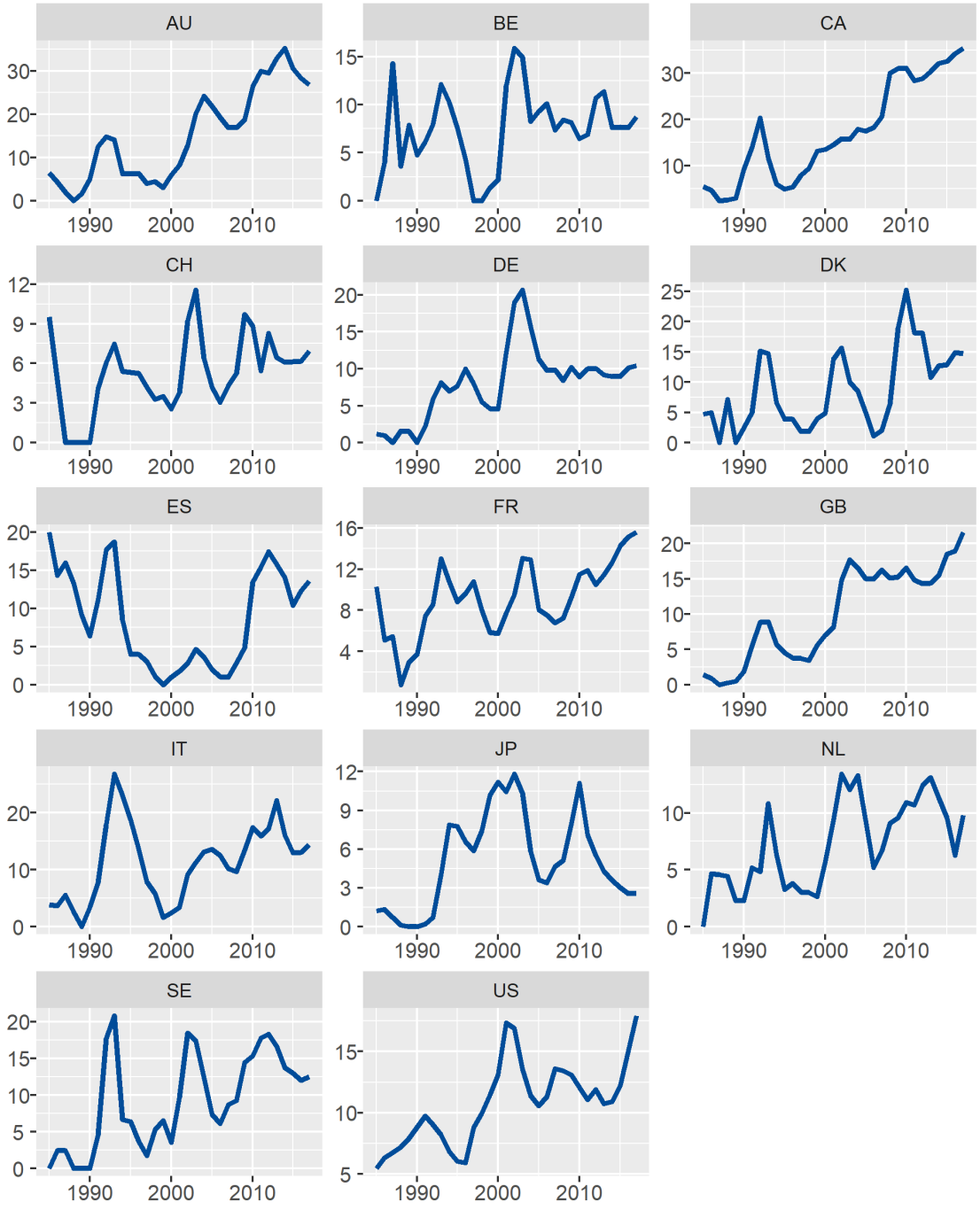
7 Our finding of a rather low zombie share in Japan is consistent with the decade-long debate on zombification in Japan. This debate highlighted that profitability-based zombie definitions (like ours) tend to yield smaller zombie shares than those based on subsidised credit (like the one of Caballero et al. (2008)) as the latter might misclassify healthy firms as zombies (see e.g. Fukuda and Nakamura (2011), Imai (2016)). Moreover, our sample of listed firms misses the post-GFC increase in non-listed low-return borrowers in Japan that has been highlighted for example by the Bank of Japan (2019).

8 This definition follows that adopted by the European Commission. Another criterion defining an SME is that the number of employees should be below 250. We do not use the employment criterion here as the reporting of employment numbers is somewhat less populated in the Worldscope database.

Zombie shares by country[1]

In per cent

Graph 3



[1] Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declasssified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

Sources: Datastream Worldscope; authors' calculations.

There is also considerable variation in zombie shares at the sectoral level (Graph 4). In particular, commodity sectors are characterised by relatively high shares of zombie firms (40%), probably reflecting the aftermath of the commodity super cycle of the past two decades. The relatively high shares of zombie firms we found for Australia, Canada and also the United States also reflects in part the relatively greater importance of the commodity sector in these economies. The second largest presence of zombie firms is in the healthcare sector. This might change in the wake of the Covid-19 shock, which could boost the profitability and stock valuations of these firms, just as it could dampen them in other sectors that used to be characterised by low degrees of zombification (e.g. retail and transportation). Finally, the printing and publishing sector also has relatively high shares. The structural challenges from digitisation could be one driver here.

The public debate usually focuses on the rising number of zombie companies as documented above. But how important are these zombie companies economically? In order to assess this question, we compute the share of zombie companies in the total assets, the capital stock and the debt of all listed non-financial corporates (i.e. total zombie assets/capital/debt as a ratio of that of all firms).[9]

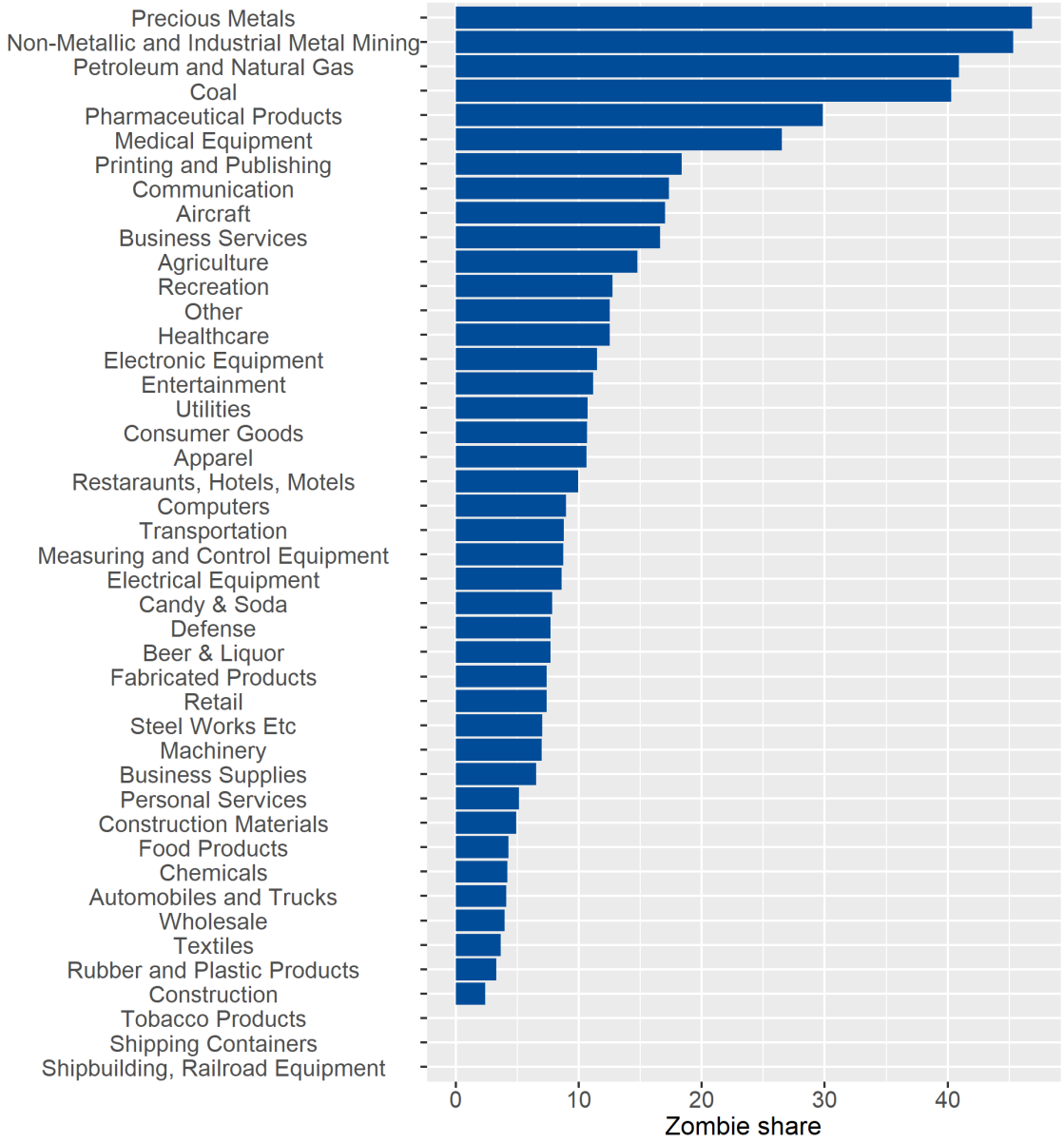
Graph 5 (left-hand panel) shows that the economic weight of zombies is lower than their number. On average, about 6%-7% of assets, capital and debt are sunk in zombie firms. This indicates that zombies tend to be smaller than non-zombie firms. More to the point, this seems to imply that zombies are probably economically less important. However, amongst listed SMEs (defined as described above), the share of zombie firms in assets, capital and debt is substantially higher at 30% - 40% (Graph 5, right-hand panel). If SMEs are more likely to be zombie firms, as our analysis suggests, the weight of zombie firms in the total economy, where unlisted SMEs in many countries play and important role, may well be larger than their weight in the population of companied listed on the stock market.

[9] We do not report the share in employment as firm employment is less consistently reported in the Worldscope database, in particular for small firms.

Zombie shares by sector[1]

In per cent, 2017 shares

Graph 4



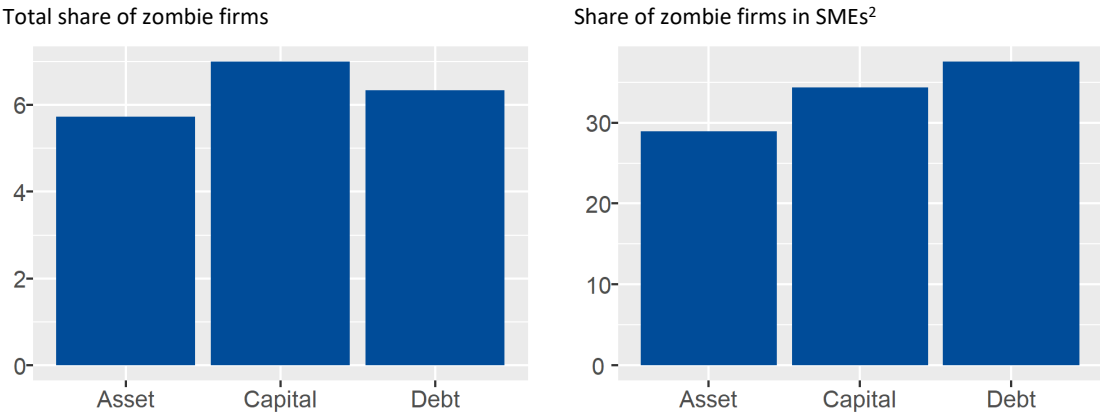
[1] Sector definitions based on Fama-French 48 sectors. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declasssified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

Sources: Datastream Worldscope; authors' calculations.

Zombie shares in assets, capital and debt[1]

In per cent, 2017 shares

Graph 5



[1] Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declasssified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required. [2] SMEs defined as firms with an annual turnover of less than 50 million US dollar.

Sources: Datastream Worldscope; authors' calculations.

3. Zombie anatomy

This section reports stylised facts about the anatomy of zombie companies. Specifically, we look at financial statements to flesh out the characteristics that distinguish them from other firms. In Table 1 we report sample averages as well as the results of Kolmogorov-Smirnoff (KS) tests for the equality of distributions of each variable between zombie and non-zombie companies.

The statistics highlight a number of key facts about the anatomy of zombie firms. Unless otherwise stated, we report in the text only the key dimensions in which the differences are statistically significant.

Zombie companies are much smaller than non-zombie firms. Assets, capital stock and employment of non-zombie firms are on average three times larger than those of zombie companies. This is consistent with the observation that we made in the previous section that the share of zombies is considerably higher amongst SMEs compared to the total population of firms.

Zombies' investment behaviour differs from that of profitable firms. They have lower capex, by about 0.5 percentage points of assets. At the same time, they also

invest less in intangible capital (i.e. research and development (R&D) and organisational capital), by about 1.2 percentage points of assets relative to non-zombies.[10]

Zombie firms' anatomy

Means[1] and tests of differences in distribution — Table 1

	Non-zombie firms[10]	Zombie firms[10]	Kolmogorov-Smirnoff stat[11]
Total assets[2]	23244.29	7361.6***	0.29
Capital stock[2,3]	16468.43	6173.27***	0.24
Employees	7075.64	2541.2***	0.25
Capex[4]	5.59	5.14***	0.15
Intangible investment[4]	6.64	5.42***	0.07
Asset disposal[4]	1.18	1.63***	0.1
Employment growth[5]	3.15	-6.56***	0.27
Labour productivity[6]	3.47	1.76***	0.38
TFP[7]	7.02	3.68***	0.26
Cash flow[4]	11.38	-5.4***	0.51
Interest coverage ratio	16.09	-17.93***	0.68
Tobin's q	2.24	1.13***	0.35
Dividends paid[4]	1.36	0.17***	0.48
Interest paid[4]	2.13	2.22	0.1
Leverage[8]	23.57	24.29***	0.11
Debt growth[5]	3.5	-7.01***	0.09
Equity Issuance[4]	8.2	9.64***	0.15
Exit probability[9]	0.04	0.085***	0.04

[1] ***/**/* indicate significant difference in means of zombie firms relative to non-zombie firms after controlling for country, sector and time fixed effects. [2] In thousands of 2010 US dollars. [3] Plant, property and equipment. [4] As a ratio of total assets. [5] Growth rate defined as $(x_t - x_{t-1})/0.5*(x_t + x_{t-1})$. [6] Labour productivity is computed following Gopinath et al. (2017) as real output divided by the real wage bill. Real output is computed as nominal value added (wage bill plus gross profits) converted into US dollars divided by the US CPI deflator. For firms with missing wage bill we follow Imrohoroglu and Tuzel (2013) and impute the wage bill using the number of employees in the firm multiplied by the average industry wage computed at the two digit SIC level. [7] TFP is the level of total factor productivity estimated using the semi-parametric estimator proposed by Levinsohn and Petrin (2003). Real value added and labour inputs are measured as for labour productivity. The real capital stock is the nominal value of fixed capital deflated by the CPI deflator. Material inputs as materials if available or operating expenses minus staff costs following Imrohoroglu and Tuzel (2013). [8] Total debt as ratio of total assets. [9] Firm exit/death where Worldscope classifies the reason for exiting the database as either: "DEAD", "MERGER", "TAKEOVER" or "LIQUIDATED". [10] Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declasssified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required. [11] Kolmogorov-Smirnoff test of differences in distribution relative to non-zombie firms. The 1% critical value of the test is 0.008 so that all tests reject the null hypothesis that the data are drawn from the same distribution.

[10] The definition follows Peters and Taylor (2017), who measure intangible investment as the sum of R&D expenditures plus 30% of selling, general and administrative expenditure to capture expenditures on organisational capital.

Zombies are shrinking their operations, as reflected in higher asset disposal and shrinking employment. Their asset disposal (i.e. cash raised through asset sales) is roughly 0.5 percentage points higher than that of their non-zombie peers. At the same time, the number of employees in zombie firms on average fell by more than 6% per year, compared to employment growth of more than 3% in other firms.

In line with previous evidence, we find that zombies are less productive than non-zombie firms. Both their labour productivity and their total factor productivity (TFP) are respectively only half the level of that of other companies.[11]

Zombies are further characterised by negative cash flow and negative ICRs as well as a low Tobin's q, essentially reflecting the way they have been defined. At the same time, they pay out lower dividends, by more than 1 percentage point of total assets compared to other companies, reflecting their lower profitability.

We find evidence that zombie firms receive subsidised credit. While interest paid relative to total assets is 0.1 percentage points higher for zombie firms, the difference to non-zombie firms is not statistically significant despite their lower profitability and greater riskiness. It would appear that properly taking into account the greater credit risk associated with lending to zombie firms should be reflected in significantly higher interest payments of these firms relative to non-zombie firms.

The table further shows that zombie companies are significantly more leveraged (measured as total debt as a ratio to total assets), but that they shrink their debt, probably reflecting efforts to reduce leverage or difficulties in obtaining sufficient credit despite being kept alive. At the same time, zombies issue significantly more equity than other firms do (relative to total assets). This result is consistent with the finding by Denis and McKeon (2018) that loss-making US corporates frequently issue equity through private placements, and use the funds raised to cover operating losses.

---

[11] Labour productivity is computed following Gopinath et al. (2017) as real output divided by the real wage bill. Real output is computed as nominal value added (wage bill plus gross profits). For firms with missing wage bill we follow Imrohoroglu and Tuzel (2013) and impute the wage bill using the number of employees in the firm multiplied by the average industry wage computed at the two digit SIC level. To compute real variables, nominal values in local currency are first converted into US dollars and then divided by the US CPI deflator. TFP is the level of total factor productivity estimated using the semi-parametric estimator proposed by Levinsohn and Petrin (2003). Real value added and labour inputs are measured as above. The real capital stock is the nominal value of fixed capital deflated by the CPI deflator. Material inputs as materials if available or operating expenses minus staff costs following Imrohoroglu and Tuzel (2013).

Finally, zombie firms face a probability of dying by exiting the market in any given period (through bankruptcy or take-over) that is more than twice as high as that of non-zombie firms: 8.5% vs. 4%.[12]

4. Zombie life cycle

As the next step, we document in this section stylised facts about the life cycle of zombie firms. How do these firms develop before morphing into a zombie? And how do they evolve afterwards? We can shed light on these questions by analysing their performance around the year when they were first classified as a zombie firm.

In order to flesh out zombie life cycle dynamics, we run local linear projection regressions of the following form:

$$y_{i,c,s,t+h} = \alpha_{c,t+h} + \alpha_{s,t+h} + \beta_h D(Enterzombie = 1)_{i,c,s,t}$$
$$+ \gamma_h D(Zombie = 1 \,\&\, Enterzombie = 0)_{i,c,s,t}$$
$$+ \theta_h X_{i,c,s,t-1} + \varepsilon_{i,c,s,t+h}$$

for *h={-4,-3,-2, -1, 0, 1, 2 ,3, 4}*. $y_{i,c,s,t+h}$ is a measure of firm performance (e.g. Capex) of firm *i* in country *c* and sector *s* in period *t+h*, $D(Enterzombie = 1)_{i,c,s,t}$ is a dummy variable that takes the value one if the firm became a zombie in period *t*. To compare newly minted zombies with healthy firms only we include as a control variable $D(Zombie = 1 \,\&\, Enterzombie = 0)_{i,c,s,t}$ which is a dummy variable that takes the value one if the firms is a zombie in period *t* but did not enter in zombie status in this period. $X_{i,c,s,t-1}$ is the (lagged) log of total assets in constant US dollars to control for the difference in size between zombie and non-zombie firms.[13] The regressions further control for country fixed effects ($\alpha_{c,t+h}$) and sector fixed effects ($\alpha_{s,t+h}$).

The coefficients β_h trace the dynamics of the firm balance sheet, profit and cashflow account variables from four years before to four years after the year when a firm was classified as a zombie. The coefficients measure zombie performance relative to non-zombie firms, so that a value above (below) zero means that the

[12] We define a firm exit/death if Worldscope classifies the reason for exiting the database as either: "DEAD", "MERGER", "TAKEOVER" or "LIQUIDATED". We do not classify a firm as having exited if it drops out of the database without one of these four reasons.

[13] Frank and Goyal (2009) show that firm size, alongside profitability and the market-to-book ratio, consistently correlates with many capital structure decisions. We only select firm size as this is not included in the zombie firm definition.

realisation of that variable was higher (lower) for zombie firms than for the non-zombie benchmark. In the following, we report the point estimates together with 95% confidence bands (clustered at the firm, country-year and industry-year level).

The results reported in Graph 6 suggest that the performance of zombie companies deteriorates significantly relative to other firms several years before the date of zombification. Their productivity declines and their assets, capital and intangible investment and employment shrink. As a mirror image of shrinking asset size, zombie firms' asset disposal is significantly above that of non-zombies and rises steeply in the years before a company becomes a zombie.

After zombification, firms improve in terms of productivity, but still do not catch up with the productivity of healthy firms. Also, four years after becoming a zombie firm, productivity is more than 1 percentage point below that of the non-zombie benchmark. At the same time, in the post-zombification years, these firms continue to shrink significantly in terms of their asset size, partly reflecting rising asset disposal. They also recover somewhat in terms of capex, intangible investment and employment growth, but still remaining well and significantly below the non-zombie benchmark.

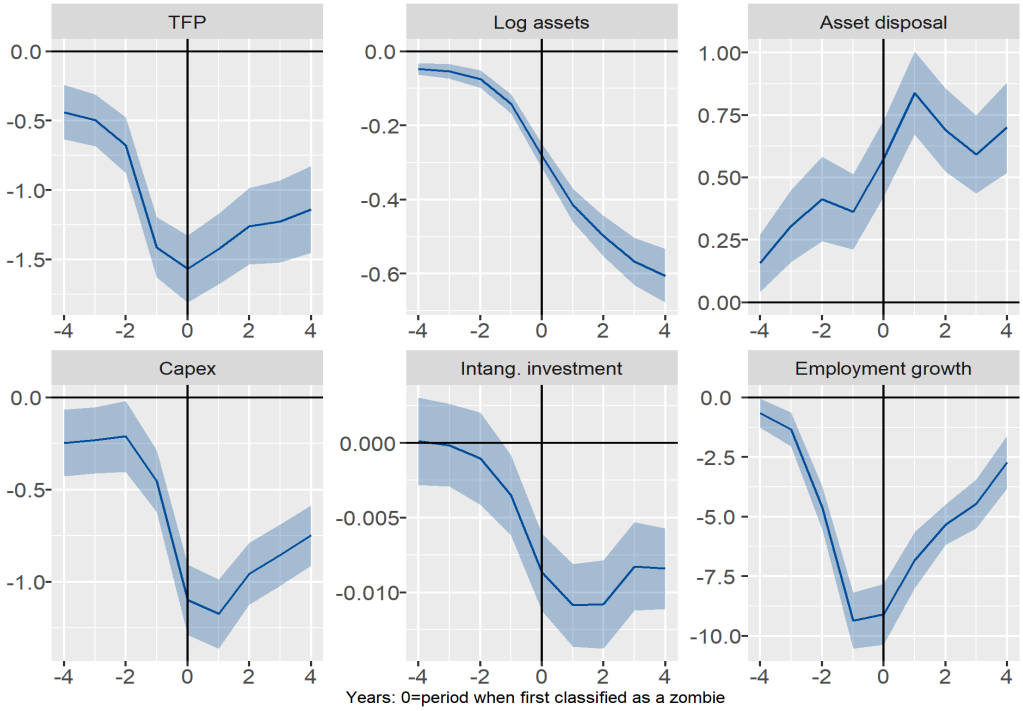
The chart further shows that cash flow and the ICR declines in the years before zombification and stays well below levels of non-zombie firms thereafter. Zombies stay afloat by issuing equity both before and after zombification, significantly more so than their profitable peers, except for the year they turn zombies when their equity issuance temporarily collapses.

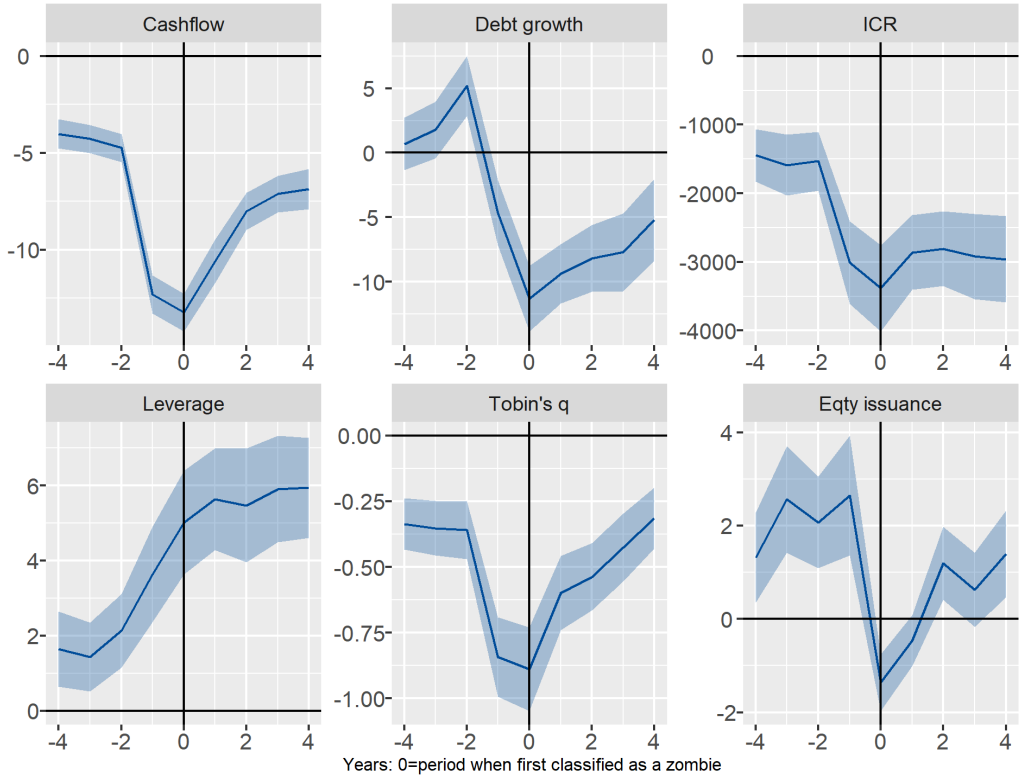
Up to two years before being classified as a zombie, a firm's indebtedness grows strongly relative to that of its non-zombie peers. Subsequently, debt accumulation drops significantly and continues to fall after the firm became a zombie. Book leverage nevertheless rises all the way relative to non-zombies in the years before zombification as assets fall at a faster rate than debt. After the date a firm has turned zombie, leverage continues to rise but at a much flatter pace.

Tobin's q deteriorates significantly in the run up to zombification. Thereafter, it rises steadily, suggesting that markets increasingly seem to expect that the firms can recover the longer they survive. Four years after zombification, Tobin's q is back to the level is was eight years earlier, but it remains significantly below the non-zombie benchmark.

Zombie firms' life cycle[1]

Graph 6





[1] Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declasssified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

Sources: Datastream Worldscope; authors' calculations.

Finally, we explore the evolution of zombie company death and recovery, i.e. the cumulative probability of a company to exit the market or return to non-zombie status. To this end, we estimate the following equation:

$$D_{i,c,s,t+h} = \alpha_{c,t+h} + \alpha_{s,t+h} + \beta_h D(Enterzombie = 1)_{i,c,s,t}$$
$$+ \gamma_h D(Zombie = 1 \,\&\, Enterzombie = 0)_{i,c,s,t}$$
$$+ \theta X_{i,c,s,t-1} + \varepsilon_{i,c,s,t+h}$$

for $h=\{1, 2, 3, 4\}$. $D_{i,c,s,t+h}$ is a dummy variable taking the value 1 respectively when a firm exited the market or recovered from zombie status in period $t+h$. As before, $D(Enterzombie = 1)_{i,c,s,t}$ is a dummy variable that takes the value one if the firm became a zombie in period t. $X_{i,c,s,t-1}$ is the (lagged) log of total assets in 2010 constant US dollars to control for the difference in size between zombie and non-zombie firms and $(Zombie = 1 \,\&\, Enterzombie = 0)_{i,c,s,t}$ is a dummy variable that takes the value one if the firms is a zombie in period t but did not enter in zombie status in this period. Also here, the regressions control for country and sector fixed effects.

Graph 7 (left-hand panel) shows that in the four years since zombification the cumulative probability of death (exit) rises by about 2 percentage points relative to non-zombie firms each year, reaching about 9 percentage points after four years. This result is consistent with the significantly higher exit rate of zombie firms on average, as shown in Table 1. With respect to the recovery of zombie firms, we find that, after four years, more than 60% recover from zombie status (Graph 7, right-hand panel).[14]

Despite the recovery, firms seem to remain weak however. Our findings on the evolution of their performance as reported above in Graph 6 suggests that recovered zombie firms continue to underperform relative to non-zombie firms. We explore this issue in more detail in the next section.

[14] Here the non-zombie benchmark probability is 0 so that the percentage point difference between the two types of firms is the same as the absolute probability of recovery of a zombie firm in %.

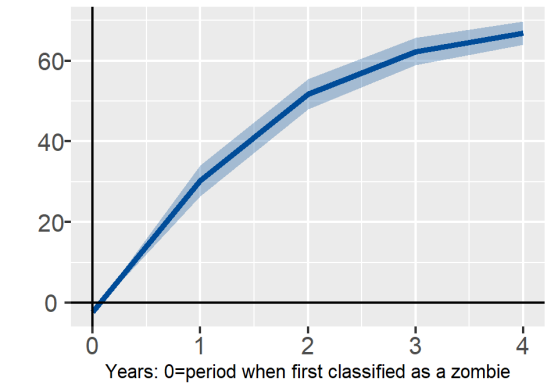
Zombie death and recovery[1]

In percentage points

Graph 7

Cumulative probability of exit

Probability of recovering from zombie status



[1] Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declasssified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

Sources: Datastream Worldscope; authors' calculations.

5. Recovered zombies

When looking at the total number of zombie cases since the mid-1980s and classifying them into recovered, deaths and active cases, we see that the majority of zombie firms recover (Graph 8, left-hand panel). Out of a total of 12,727 zombie cases, about 60% (8,060) have recovered, while a quarter (2,955) have died through market exit. The number of active cases has remained relatively stable since the GFC at around 1,800.

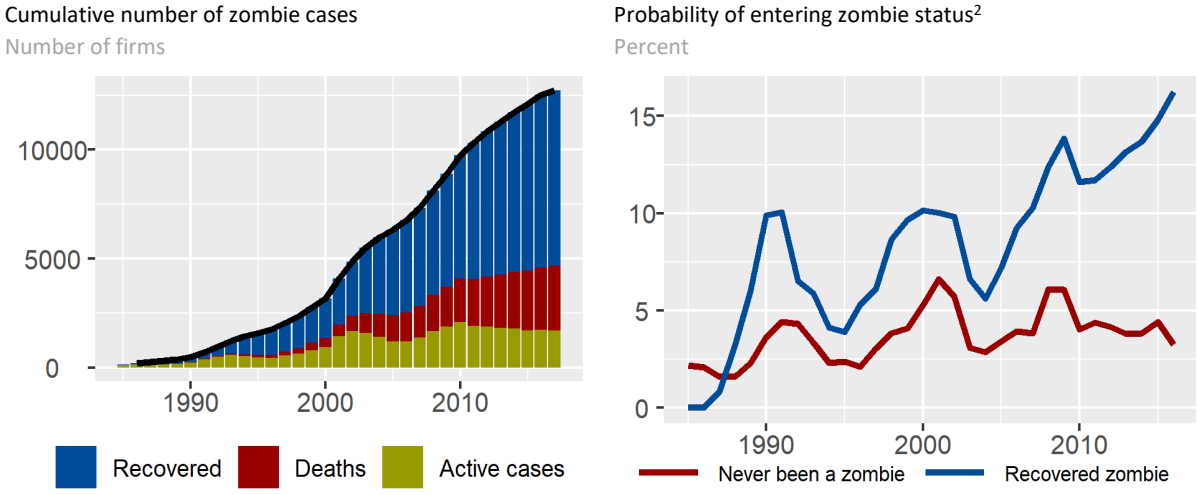
Does this observation mean that the zombie problem is just an illusion? Are zombies just firms that experience temporary hardship but can ultimately fully recover? In order to address this question, we have to zoom in on these recovered zombies to get an idea about their longer term "health" status.

As a first step, we assess how sustained the recovery of former zombie firms is. To this end, we first compare the likelihood that they return to zombie status from one period to the next with that of firms that have never been classified as zombies before (Graph 8, right-hand panel). The probability of a recovered zombie being classified as a zombie firm in period T is calculated as the number of firms that have recovered at least once from zombie state in years $t<T$ but were classified as a zombie in year T divided by the number of firms that have recovered at least

once from being a zombie. The probability that a firm is classified as a zombie that has never been a zombie is calculated by the number of firms that have never been classified as a zombie in periods $t<T$, but were classified as a zombie firm in period T divided by the number of firms that have never been classified as a zombie in period $t<T$.

It turns out that recovered zombie firms face a high probability of relapse and that this probability has increased considerably over recent years. In 2017, our last data point, a recovered zombie firms faced a probability of becoming a zombie firm in the next period of about 17% (blue line), up from a probability of about 5% in 2005. This compares to a probability of turning zombie in the next period of about 3% for firms that were never zombies before, essentially unchanged compared to the probabilities over the past two decades (red line).

What happens to zombie firms? Graph 8



[1] Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declasssified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required. [2] "Never been a zombie" are firms which in period T have not been classified as a zombie firm in periods $t<T$. "Recovered zombie" are firms which in period T have been classified as a zombie at least once in periods $t<T$.

Sources: Datastream Worldscope; authors' calculations.

As the next step, we explore the anatomy of recovered zombies similar to the way we assessed the anatomy of zombies before, focusing on a number of key performance indicators. The reference point are again firms that have never been zombie firms.

We find that, as well as being more likely to relapse into zombie status, recovered zombie firms are also systematically weaker than firms that have never been zombies (Table 2). They are significantly smaller in terms of assets, capital stock and employment. More importantly, they are also less dynamic and

productive. Recovered zombies invest significantly less in physical and intangible capital and the number of their employees expands at less than half the rate of firms that were not previously classified as a zombie. At the same time, their productivity, both labour productivity and TFP, is significantly lower than that of their immaculate peers.

Overall, these results suggest that there seems to be a growing corporate precariat characterised by mediocre performance and a material risk of relapsing into zombie status. The headline figures of zombie firms reported above may therefore understate the true extent of weaknesses and risks present in advanced economy corporate sectors.

Recovered zombie firms' anatomy

Means[1] and tests of differences in distribution — Table 2

	Never zombie firms[7]	Recovered zombie firms[8]	Kolmogorov-Smirnoff stat[9]
Total assets[2]	25023.8	14418.1***	0.29
Capital stock[2]	17535.81	10934.46***	0.24
Employees	7541.85	4754.24***	0.25
Capex[3]	5.73	5.02***	0.15
Intangible investment[3]	6.87	5.6***	0.07
Employment growth[4]	3.4	1.45***	0.27
Labour productivity[5]	3.53	3.11***	0.38
TFP[6]	7.32	5.6***	0.26

[1] ***/**/* indicate significant difference in means of zombie firms relative to non-zombie firms after controlling for country, sector and time fixed effects. [2] In thousands of 2010 US dollars. [3] As a ratio of total assets. [4] Growth rate defined as $(Employment_t - Employment_{t-1})/0.5*(Employment_t + Employment_{t-1})$. [5] Labour productivity is computed following Gopinath et al. (2017) as real output divided by the real wage bill. Real output is computed as nominal value added (wage bill plus gross profits) converted into US dollars divided by the US CPI deflator. For firms with missing wage bill we follow Imrohoroglu and Tuzel (2013) and impute the wage bill using the number of employees in the firm multiplied by the average industry wage computed at the two digit SIC level. [6] TFP is the level of total factor productivity estimated using the semi-parametric estimator proposed by Levinsohn and Petrin (2003). Real value added and labour inputs are measured as for labour productivity. The real capital stock is the nominal value of fixed capital deflated by the CPI deflator. Material inputs as materials if available or operating expenses minus staff costs following Imrohoroglu and Tuzel (2013). [7] Firms that have never previously been classified as a zombie. [8] Firms that have recovered at least once from zombie status in years t<T. [9] Kolmogorov-Smirnoff test of differences in distributions relative to non-zombie firms. All tests reject the null hypothesis that the data are drawn from the same distribution. The 1% critical value of the test is 0.008 so that all tests reject the null hypothesis that the data are drawn from the same distribution.

6. Conclusions

Our analysis shows that the share of zombie companies has increased considerably over the past three decades, rising from 4% in the late 1980s to 15% in 2017. Zombie firms account for about 6%-7% of all listed companies' assets, capital and debt. This does not, however, mean that the zombie problem is negligible from an economy-wide point of view. It is important to bear in mind that, in order to cover a longer sample period and due to the way zombie firms are identified based on

their actual profitability and their stock market valuation, our analysis covers only listed companies, missing out in particular on the population of unlisted SMEs which in some countries is large. If small firms are more likely to be zombified, as our analysis suggests, then the economic weight of zombies may be greater than indicated by our analysis. Indeed, amongst listed SMEs, the share of assets, capital and debt sunk in zombie firms is as high 30% - 40%.

Our analysis of the zombie anatomy and life cycle indicates that zombie firms are significantly smaller as well as less productive and dynamic than other firms. However, our analysis also shows that the majority of these firms manage to recover, rather than exiting the market or remaining in zombie status. Yet, closer inspection shows that those firms that do recover from zombification remain weak and a drag on economic dynamics. They have a high probability of relapsing into zombie status and their dynamism and productivity is significantly lower than that of firms that have never been zombies in their life. In other words, the zombie disease seems to cause long-term damage also on those that recover from it. The weakness and risks in advanced economy corporate sectors may therefore not be fully captured by headline figures of the number of zombie firms.

Our results underline the challenge the authorities face when taking measures to contain the impact of the coronavirus recession on firms. The delicate task is to seek to shore up companies that would be viable in less extreme circumstances while at the same time not excessively dampening corporate dynamism by protecting already weak and unproductive ones. A firm's viability should be an important criterion for its eligibility for government and central bank support.[15]

[15] One possible way to address this issue is to make government support dependent on the profitability of a firm, e.g. by following the proposal by Carstens (2020) to link tax deferral loans to a firm's profitability in the previous year.

References

Acharya, V, T Eisert, C Eufinger and C Hirsch (2019a): "Whatever it takes: the real effects of unconventional monetary policy", *The Review of Financial Studies*, 32 (9), pp 3366-3411.

Acharya, V, T Eisert, C Eufinger and C Hirsch (2019b): "Zombie credit and (dis-)inflation: Evidence from Europe", *mimeo*, New York University.

Adalet McGowan, M, D Andrews and V Millot (2017): "The walking dead: Zombie firms and productivity performance in OECD countries", *OECD Economics Department Working Papers*, no 1372.

Almeida, H and M Campello (2007), "Financial constraints, asset tangibility, and corporate investment", *The Review of Financial Studies*, 20(5), pp 1429–1460.

Andrews, D and F Petroulakis (2017): "Breaking the shackles: weak banks and depressed restructuring in Europe", *OECD Economics Department Working Papers*, no 1433.

Armstrong, R (2020): "How to avoid a corporate zombie apocalypse", *Financial Times*, 5 February 2020.

Autor, D, D Dorn, L Katz, C Patterson and J Van Reenen (2017): "The fall of the labor share and the rise of superstar firms", *NBER Working Papers*, no 23396.

Banerjee, R and B Hofmann (2018): "The rise of zombie firms: Causes and consequences", *BIS Quarterly Review*, September, pp 67-78.

BIS (2018): Annual Economic Report 2018, June.

Caballero, R, T Hoshi and A Kashyap (2008): "Zombie lending and depressed restructuring in Japan", *American Economic Review*, vol 98, no 5, pp 1943–77.

Carstens, A (2020): "Bold steps to pump coronavirus rescue funds down the last mile", *Financial Times*, 29 March 2020 (also available at https://www.bis.org/speeches/sp200330.htm).

Denis, D and S McKeon (2018): "Persistent operating losses and corporate financial policies", mimeo, University of Pittsburgh.

Financial Times (2020): "Reasons to fear the march of the zombie companies", *Financial Times,* Editorial Board, 24 June 2020.

Fons-Rosen, C, S Kalemli-Ozcan, B Sorensen, C Villegas-Sanchez and V Volosovych (2013): "Quantifying productivity gains from foreign investment", *NBER Working Papers*, no 18920.

Foster, L, C Grim and J Haltiwanger (2016): "Reallocation in the Great Recession: Cleansing or not?", *Journal of Labour Economics*, 34 (S1), pp S293-S331.

Frank, M and V Goyal (2009): "Capital structure decisions: Which factors are reliably important?", *Financial Management*, vol 38(1), pp 1-37.

Fukuda, S and J Nakamura (2011): "Why did 'zombie' firms recover in Japan?", *World Economy*, vol 34 (7), pp 1124–1137.

Gopinath, G, S Kalemli-Ozcan, L Karabarbounis and C Villegas-Sanchez (2017): "Capital allocation and productivity in south Europe". *The Quarterly Journal of Economics* 132(4) pp 1915-1967.

Imai, K (2016): "A panel study of zombie SMEs in Japan: identification, borrowing and investment behaviour", *Journal of the Japanese and International Economies*, vol 39, pp 91–107.

İmrohoroğlu, A and Ş Tüzel (2014): "Firm-level productivity, risk, and return", *Management Science,* vol. 60(8), pages 2073-2090.

Levinsohn J and A Petrin (2003): "Estimating production functions using inputs to control for unobservables", *The Review of Economic Studies*, vol 70(2), pp 317–341.

Lynch, D (2020): "Here's one more economic problem the government's response to the virus has unleashed: Zombie firms", *The Washington Post*, 23 June 2020.

Peters, R and L Taylor (2017): "Intangible capital and the investment-q relation", *Journal of Financial Economics*, vol 123(2), pp 251-272.

Rajan, R and L Zingales (1998): "Financial dependence and growth", *American Economic Review,* vol 88(3), pp 559-86.

Schivardi, F, E Sette and G Tabellini (2017): "Credit misallocation during the European Financial Crisis", *BIS Working Papers*, no 669, December.

Sharma, R (2019): "When dead companies don't die", *New York Times*, 15 June 2019.

Storz, M, M Koetter, R Setzer and A Westphal (2017): "Do we want these two to tango? On zombie firms and stressed banks in Europe", *ECB Working Papers*, no 2104.

Taylor, C (2019): "Why 'zombie' companies are on the rise - and could pose a threat to the U.S. economy", *Fortune*, 2 September 2019.

Appendix 1: Zombies and the wider economy

Previous studies have found that zombie companies weaken economic performance (Caballero et al. (2008) and Adalet McGowan et al. (2017)). Zombies are less productive and crowd out growth in more productive firms by locking resources (so-called "congestion effects"). Specifically, they may depress the prices of those firms' products, raise their wages and their funding costs, by creating excess capacity in a sector.

In order to test whether zombie firms identified according to our definition also give rise to such congestion effects, and thus to test the plausibility of the definition from another angle assuming that only true zombies would give rise to such effects, we run the following panel regression

$$y_{i,s,c,t} = \alpha_{s,t} + \gamma_{c,t} + \beta_1 D(nonzombie\ firm)_{i,s,c,t} + \beta_2 D(nonzombie\ firm)_{i,s,c,t} * zombie\ share_{s,t-1} + \beta_3\, log\left(size_{i,s,c,t}\right) + \beta_4 firm\ age_{i,s,c,t} + \varepsilon_{i,s,c,t}.$$

The dependent variable $y_{i,s,c,t}$ is either capital expenditures as a ratio lagged physical capital, employment growth or debt growth defined as $\frac{x_{it}-x_{it-1}}{0.5(x_{it}+x_{it-1})}$ and equity issuance as a ratio of lagged total assets in firm i in sector s of country c in year t. $\alpha_{s,t}\ and\ \gamma_{c,t}$ are sector*year and country*year fixed effects, respectively. The variable *D(non zombie firm)* is a dummy variable taking the value of one if the firm is not a classified as a zombie. *zombie share* is the share of total assets in zombie firms in a given sector in a year.

The results suggest that zombie firms give rise to significant congestion effects (Table A1). This is reflected in a negative and statistically significant coefficient for the interaction term between non-zombies and the zombie share. Specifically, the estimation results suggest that a 1 percentage point increase in the zombie share in a sector lowers the capital expenditure (capex) rate of non-zombie firms by around 1 percentage point, a 10 per cent reduction relative to the mean investment rate. Similarly, employment growth is 0.16 percentage points lower, a 5 per cent reduction. However, under both definitions we find that non-zombie companies invest more and have higher employment growth (first row in Table A1), consistent with the results we reported in Table 1.

Zombie firms are therefore not only less productive, but also hinder the growth of more productive firms. However, from these findings we can still not infer the wider effect of zombie firms on productivity growth. They may be significantly less

productive and give rise to significant congestion effects, but the effects may quantitatively still be too small to affect aggregate productivity growth.

Zombie congestion effects on non-zombie firms[1] Table A1

	Capex	Employment growth	Debt growth	Equity issuance
D(Non zombie firm)	0.421***	0.107***	0.122***	3.148***
D(Non zombie firm) * zombie share	-0.454**	-0.156***	-0.334***	-10.156**
Firm age and log size controls	Yes	Yes	Yes	Yes
Sector*year and country*year effects	Yes	Yes	Yes	Yes
No of observations	221,861	237,519	210,982	209,005
R-squared	0.265	0.071	0.028	0.099

[1] Significance at the 1/5/10% level denoted by ***/**/*; standard errors are double clustered by country and sector. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declasssified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

Sources: Datastream Worldscope; authors' calculations.

We assess the economy wide impact on productivity from the rise in zombie firms using a Bartik/shift-share instrument. In particular, to assess the productivity impact, we isolate the rise in a country's zombie share only due to the exposure of its asset stock to the global industry trends in zombification to reduce potential endogeneity issues related to domestic factors. To this end, we run the following instrumental variable panel regression

$$TFP\ growth_{c,t} = \alpha_c + \gamma_t + \beta_1 zombie\ share_{c,t-1} + \beta_2 output\ gap_{c,t-1} + \beta_3 TFP\ growth_{c,t-1} + \varepsilon_{c,t}.$$

The asset weighted $zombie\ share_{c,t}$ in country *c* in year *t* is instrumented with a shift-share instrument which measures zombie exposure of a country to the global zombie share, i.e. $\sum_{i=1}^{I} assetshare_{i,c,t} zombieshare_{i,t}$, where $assetshare_{i,c,t}$ is the share of total assets in industry *i* in country *c* in year *t* and $zombieshare_{i,t}$ is the zombie share in industry *i* across all 14 economies in our sample in year *t*. α_c *and* γ_t are country and year fixed effects, respectively.

We find that when the zombie share increases, productivity growth declines significantly (Table A2). The estimates indicate that an increase in the zombie share in an economy by one percentage point lowers productivity growth by around 0.1 percentage points in the long run. A back-of-the-envelope calculations suggest that the increase in the share of zombie firms by about 10 percentage points since the late 1980s may have depressed aggregate productivity growth by about 1

percentage point, about half of the overall slowdown registered over the period. We also estimate its effect on the level of TFP (column (2)). Here we find that a 1 percentage point increase in the zombie share lowers to level of TFP by 2.5 percentage points in the long run.

Zombie firms and aggregate productivity[1] Table A2

	TFP growth[2]	Log TFP[2]
Zombie share	-0.074**	-0.076
Lagged TFP growth	0.290***	
Lagged log TFP		0.969***
Long-run effect	–0.10***	–2.45***
Country, year fixed effects	Yes	Yes
No of observations	377	377

[1] Significance at the 1/5/10% level denoted by ***/**/*; standard errors are double clustered by country and sector. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declasssified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

Sources: OECD; Datastream Worldscope; Penn World Tables; authors' calculations.

Previous volumes in this series

881 September 2020	Data vs collateral	Leonardo Gambacorta, Yiping Huang, Zhenhua Li, Han Qiu and Shu Chen
880 August 2020	Rise of the central bank digital currencies: drivers, approaches and technologies	Raphael Auer, Giulio Cornelli and Jon Frost
879 August 2020	Corporate Dollar Debt and Depreciations: All's Well that Ends Well?	Julián Caballero
878 August 2020	Which credit gap is better at predicting financial crises? A comparison of univariate filters	Mathias Drehmann and James Yetman
877 August 2020	Export survival and foreign financing	Laura D'Amato, Máximo Sangiácomo and Martin Tobal
876 August 2020	Government banks, household debt, and economic downturns: The case of Brazil	Gabriel Garber, Atif Mian, Jacopo Ponticelli and Amir Sufi
875 August 2020	The Impact of credit risk mispricing on mortgage lending during the subprime boom	James A Kahn and Benjamin S Kay
874 August 2020	Demographic origins of the decline in labor's share	Andrew Glover and Jacob Short
873 July 2020	Effects of Fed policy rate forecasts on real yields and inflation expectations at the zero lower bound	Gabriele Galati and Richhild Moessner
872 July 2020	Effects of credit restrictions in the Netherlands and lessons for macroprudential policy	Gabriele Galati, Jan Kakes and Richhild Moessner
871 July 2020	The Matthew effect and modern finance: on the nexus between wealth inequality, financial development and financial technology	Jon Frost, Leonardo Gambacorta and Romina Gambacorta
870 July 2020	International spillovers of forward guidance shocks	Callum Jones, Mariano Kulish and Daniel M Rees
869 June 2020	How well-anchored are long-term inflation expectations	Richhild Moessner and Előd Takáts
868 June 2020	Debt De-risking	Jannic Cutura, Gianpaolo Parise and Andreas Schrimpf

All volumes are available on our website www.bis.org.